(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 339 279 A2

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 89105530.3

(22) Date of filing: 29.03.89

(51) Int. Cl.4: C23C 16/04 , C23C 16/32 , C30B 31/14

The title of the invention has been amended (Guidelines for Examination in the EPO, A-III, 7.3).

The title of the invention has been amended (Guidelines for Examination in the EPO, A-III, 7.3).

(30) Priority: 31.03.88 US 175707

(43) Date of publication of application: 02.11.89 Bulletin 89/44

(84) Designated Contracting States: BE CH DE FR GB IT LI LU NL

(71) Applicant: AIR PRODUCTS AND CHEMICALS, INC.
Route no. 222
Trexlertown Pennsylvania 18087(US)

(72) Inventor: Miller, Michael Brant
551 The Meadows Parkway
Desoto Texas 75115(US)

(74) Representative: Dipl.-Ing. Schwabe, Dr. Dr. Sandmair, Dr. Marx
Stuntzstrasse 16
D-8000 München 80(DE)

(54) **Wafer holder for use in rapid thermal processing equipment and method for its manufacture.**

(57) A semiconductor wafer holding and support fixture having a low effective thermal mass comprises a planar surface having a recess for a wafer and consisting essentially of chemical vapor deposited silicon carbide. The wafer holder is specifically designed to isolate the wafer from regions of significant thermal mass of the holder. The wafer holder is particularly adapted for accomplishing chemical reactions in rapid thermal processing equipment in the fabrication of electronic integrated circuits. The method for making such an article comprises shaping a substrate, e.g. graphite, to provide a planar surface having a recess, installing means for masking any regions of the substrate where silicon carbide is not desired, chemically vapor depositing a conformal outer coating of silicon carbide onto the substrate, removing the means for masking and removing the graphite by machining, drilling, grit-blasting, dissolving and/or burning.

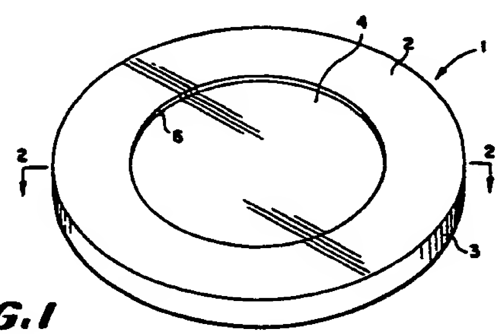

FIG. 1

EP 0 339 279 A2

comprises silicon carbide deposited onto graphite. In those cases were such rigidity is not required, the graphite can be removed as set forth below to leave the annulus hollow. If the graphite is allowed to remain in the annulus, it is essential that the annulus be sufficiently remote from the recess as allowed by the reaction chamber design and by the thin cross-section of the silicon carbide planar surface or membrane between the annulus and the wafer. This means that the semiconductor wafer being processed is isolated from any significant thermal mass of the holder and will provide the necessary rapid thermal response of the wafer.

The method for making the fixture comprises shaping a block of graphite or other suitable substrate material into the desired configuration for the particular RTA or RTP application. The minimum shaping requires that the substrate includes a planar surface containing the recess. Means for masking are provided for those regions of the substrate which are not to receive a CVD coating of silicon carbide, i.e. those regions in which the substrate is to be removed. Such masking means are provided at least in those regions on the backside of the fixture adjacent to the wafer recess. The substrate is then chemical vapor deposited with silicon carbide in a manner, for example, as that set forth in U.S. Patent No. . The silicon-containing gas used to form the silicon carbide coating can be selected from the group consisting of silicon tetrachloride, silane, chlorosilane, trichlorosilane, methyl trichlorosilane and dimethyl dichlorosilane If silicon tetrachloride, silane, dichlorosilane or trichlorosilane is used, it is necessary to supply a source of carbon to produce silicon carbide. The source of carbon can be any hydrocarbon, preferably low molecular weight aliphatic hydrocarbons such as paraffins, alkenes and alkynes having 1 to 6 carbon atoms, and aromatics and other hydrocarbons having 1 to 6 carbon atoms which do not contain oxygen. Particularly suitable examples include, methane, ethane, propane, butane, methylene, ethylene, propylene, butylene, acetylene, and benzene.

The substrate is removed in the region immediate adjacent to the wafer recess, which region has not been coated with silicon carbide. This can be done by machining, grit-blasting, drilling, dissolving or burning. Japanese Kokai Patent No. 62-124909, published 6 June 1987, describes various methods for removing substrate material in the method of making ceramic reaction tubes used in the semiconductor manufacture in which the substrate is first chemically vapor deposited with silicon carbide and the substrate is then removed by combustion or dissolution with a suitable acid or solvent.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, the accompanying drawings are provided in which:

FIGURE 1 is a perspective view of one embodiment of the wafer holding fixture of the present invention having a solid recess;

FIGURE 2 is a cross-sectional view of the fixture taken through 2-2;

FIGURE 3 is a cross-sectional view of another embodiment of the fixture having an annular section;

FIGURE 4 is a cross-sectional view of the FIGURE 3 placed within a typical RTP unit;

FIGURE 5 is a perspective view of still another embodiment of the fixture of the present invention having a recess with an opening therethrough with a cut-away section showing the annulus;

FIGURE 6 is a cross-sectional view of the substrate which has been shaped into the configuration that is used to form the fixture of FIGURE 5; and

FIGURE 7 is a cross-sectional view of one of the two masks used to form the fixture of FIGURE 5.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIGURES 1 and 2 wafer holder 1 consisting of CVD silicon carbide has upper planar surface 2 and sidewall 3 each having a thickness in the range of about 0.015 to about 0.025 inches. Planar surface 2 has solid recess 4 having a depth substantially the same as the thickness of holder 1 and has inner rim 6 and outer rim 7.

FIGURE 3 illustrates another embodiment of the present invention in which holder 10 has upper planar surface 12, sidewall 13 and hollow annular section or annulus 14. Planar surface 12 has inner rim 15, outer rim 16 and solid recess 17 having outer edge 19 separated from inner rim 15 of planar surface 12 by the thickness of the CVD SiC. The width of hollow annulus 14, from inner sidewall 20 to sidewall 13, is less than 50% of the distance from inner rim 15 to outer rim 16 of planar surface 12 so that annulus 14 is sufficient distal to outer edge 19 of recess 17 to allow for the necessary rapid response time for the thermal change of the wafer and holder 10 in the RTA or RTP systems.

FIGURE 4 illustrates holder 1 positioned within typical RTP system 21 comprising black body sources 22 and 24 so that sidewall 34 matches the

In the embodiment shown in FIGURE 30, the graphite core is removed by drilling a series of holes in inner wall 45 and support 30 is then placed in a furnace and heated to about 1200° C to burn out the graphite that remains in graphite core 46. If it is believed necessary, the fixture can be returned to the CVD reactor to coat over any of the holes.

The example below illustrates the foregoing process of preparing the fixtures of the present invention.

EXAMPLES

Example 1

Three components composed of SiC6 graphite supplied by Toyo Tanso Ltd. were fabricated into the shapes corresponding to FIGURE 6 and two masks in the shape of FIGURE 7. The component of FIGURE 5 had approximately 6 inches (15.24 cm.) outside diameter and 0.5 inches (1.27 cm.) thick. The thickness of sidewall 58 of space 56 was approximately 0.25 inches (0.635 cm.), the thickness of wall 69 of recess 68 and of wall 72 of recess 55 were each 0.025 inch (0.064 cm.). The three SiC6 graphite components were subsequently purified at 2000° C with chlorine gas in a CVD reactor serving as a purification vessel. The three components were assembled with the 2 masks illustrated in FIGURE 7 were placed into recess 68 and space 56 as set forth above. The assembly was placed into a CVD reactor and 0.025 inch of SiC was deposited onto its exposed surfaces by the pyrolysis of methyl trichlorosilane at 1250-1300° C.

Subsequent to the CVD deposition step, the upper mask (not shown) was removed by making a single point diamond cut at juncture 71. Lower mask 60 was easily removed as there was substantially no coating at juncture 64 between sidewall 58 and inner surface 59 because of diffusion limitations during the deposition process. A hole was machined through the central region of disk 50 of substantially the same diameter as the diameter of recess 56. The coated disk 50 was flipped over and the uncoated graphite was machined to within 1/16 inch from the SiC on the backsides of upper planar surface 52 and annular surface 65. The remaining graphite was grit-blasted away backside of disk 40 which left a holder having sidewall, upper planar surface and recess containing a substantially silicon carbide of 0.025 inch, with an open central region, and a region of residual graphite which was not removed, which forms annulus 46. This structure was then placed back into the CVD reactor and the exposed graphite surface of inner sidewall of annulus 46 was coated with an additional 0.007 inch of SiC. The resulting holder 30 illustrated in FIGURE 5 was removed from the reactor.

Holder 30 has been calculated to have a heat capacity of only about 10 calories° C. This over one magnitude less heat capacity of a holder prepared by CVD coating the graphite substrate with silicon carbide, which was calculated to have a heat capacity of about 113 calories/° C. Therefore, the heat-up rate of the support of the present invention in a uniform heat flux will be over 10 times that of prior art CVD coated graphite supports.

Example 2

An alumina substrate is prepared in the form of a disk substantially in the shape of FIGURE 1 having a recess in its upper planar surface and a thickness substantially the same as the desired thickness of the sidewall of the wafer support. The alumina is coated on all surfaces with a slurry of graphite powder in water and the powder is allowed to dry. The substrate is placed on a flat, circular graphite plate having a somewhat larger diameter than the disk which serves to mask the backside of the support from deposition of SiC. The substrate on the plate is then placed into a CVD reactor and is coated with a uniform coating of SiC having a thickness of about 20 thousandth of an inch. After the deposition, a single point diamond cut is made at the juncture of the substrate with the graphite plate in order to remove the substrate from the plate. The substrate of alumina coated with graphite powder has a higher coefficient of thermal expansion than the silicon carbide and will have shrunken away from the coating on cooling from deposition temperatures. The graphite powder coating will assist in preventing adhesion of the SiC coating to the substrate and the substrate can easily be removed from the silicon carbide part. The lower edge where the single point cut is made is smoothed with a diamond grinding step and lightly grit blasted on the lower surface. This will remove and residual graphite powder. Should an open recess area be provided as in FIGURE 5 to further reduce the thermal mass in the vicinity of the wafer, the opening can be diamond machined or ground into the final part.

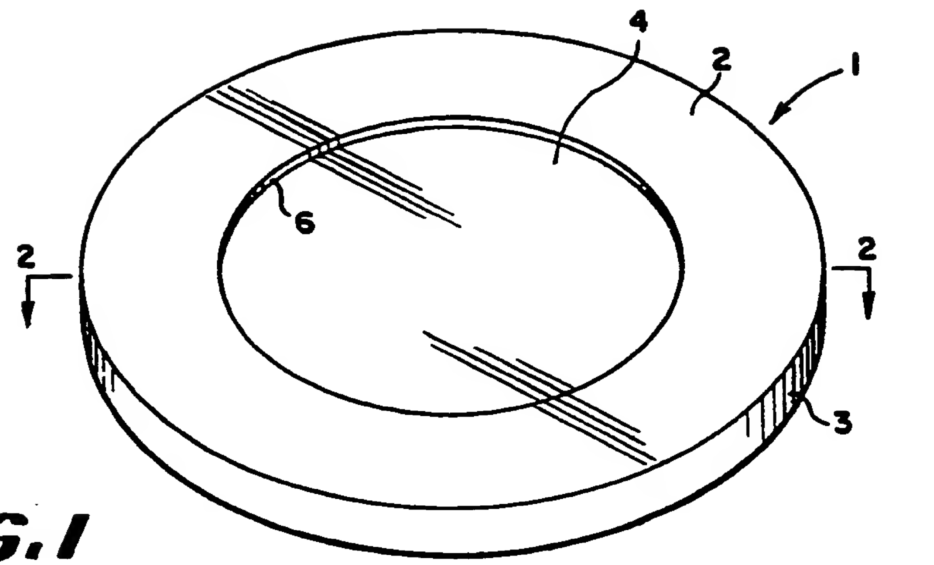

FIG. 1

FIG. 2

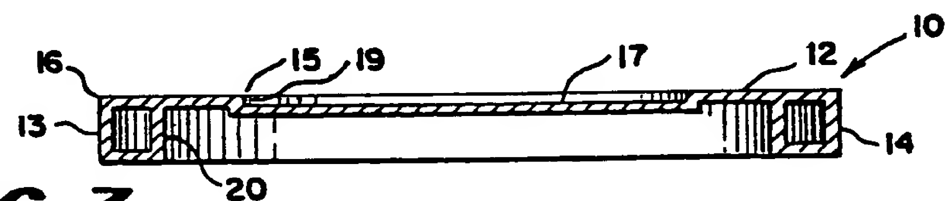

FIG. 3

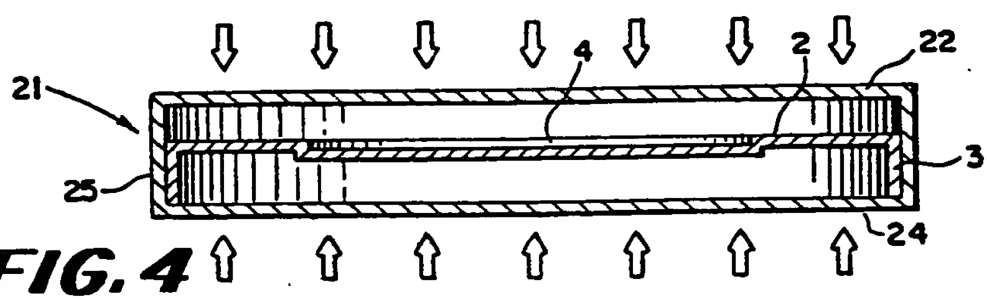

FIG. 4